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ARLINGTON WASTEWATER TREATMENT PLANT: RESULTS OF A LIMITED CLASS II INSPECTION AND RECEIVING WATER SURVEY

by

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ABSTRACT

A limited Class II inspection at Arlington Wastewater Treatment Plant and a concomitant receiving water survey in the Stillaguamish River were conducted by Ecology in September 1986. The plant was operating well and effluent was in compliance with NPDES permit limits. However, split sample analyses indicated the need for a more detailed review of plant laboratory procedures. The receiving-water-to-effluent dilution ratio at summer low flow was 1400:1. Location of a new outfall line provided excellent dilution and dispersion of effluent, and wastewater discharge had minimal impact on riverine water quality. Unfortunately the new line was again lost to high flows this past winter and effluent is once more being diverted to a side channel of the river which ponds during low flows. Design of a replacement outfall line should protect against the high flows and unstable sediments characteristic of this portion of the river.

INTRODUCTION

The city of Arlington (pop. 2,500) is located in northwestern Snohomish County at the confluence of the North and South forks of the Stillaguamish River. Arlington Wastewater Treatment Plant (WTP) processes domestic sewage from residential and light commercial activities in town. Treatment consists of comminution, aeration in an oxidation ditch, clarification, and disinfection with chlorine (Figure 1). Effluent discharge to the Stillaguamish River (Class A) is regulated by National Pollutant Discharge Elimination System (NPDES) permit WA-002256-0(M), issued April 9, 1985.

The WTP outfall is located several hundred feet downstream of the North and South Fork confluence, about 20 feet from the right river bank (Figure 2). The original WTP outfall was destroyed by high flows in the winter of 1975. In response, the city diverted the effluent to a side channel of the river. During summer low flows, however, a gravel bar isolated the channel and WTP effluent ponded. Public health concerns led to installation of a new outfall line in September 1985.

The Stillaguamish River near Arlington is a popular recreational area (swimming, fishing, boating) as well as a migration corridor for anadromous salmonids. As a result, the Northwest Regional Office (NWRO) of Ecology asked the Water Quality Investigations Section (WQIS) to conduct an intensive survey to assess diffuser adequacy and water quality impacts. A limited Class II inspection of the WTP complemented the receiving water work. Study objectives were:

- Evaluate removal efficiency and permit compliance at Arlington WTP.
- Characterize the effects of WTP effluent on the Stillaguamish River during the summer low-flow period.

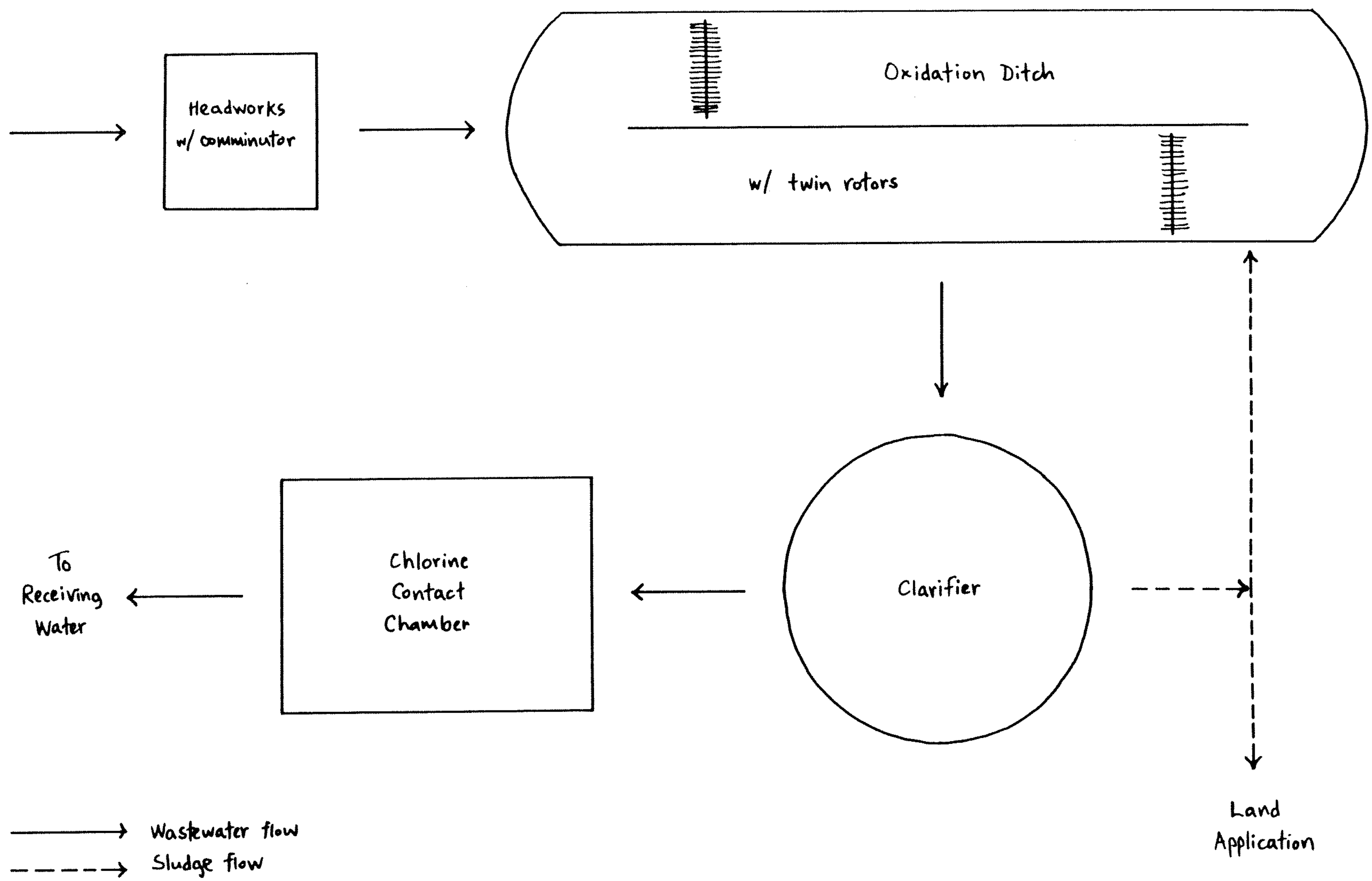

Figure 1. Wastewater and sludge flow diagram of Arlington WTP.

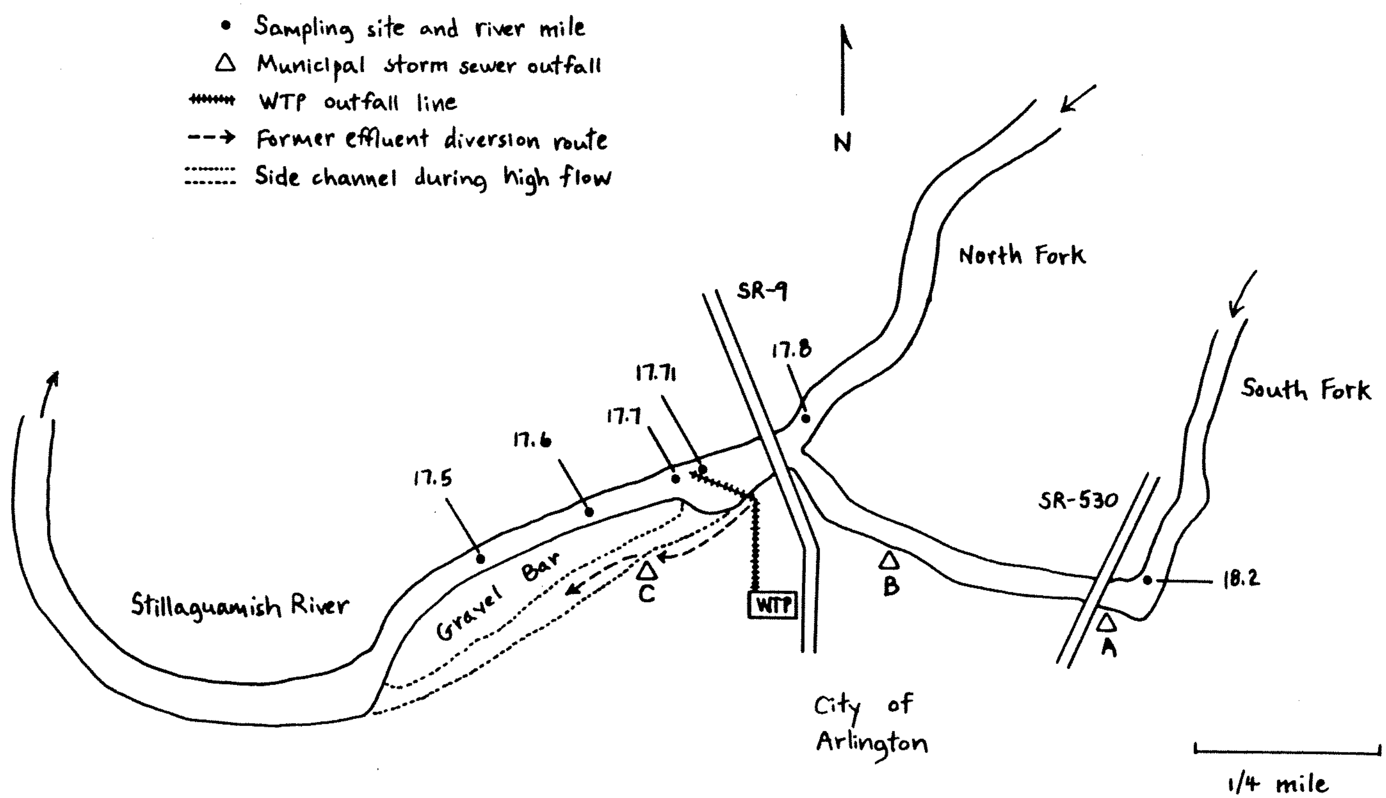

Figure 2. Map of Stillaguamish River at confluence of North and South Forks, showing location of Arlington WTP outfall and receiving water sampling sites.

Field support was provided by Joe Joy of WQIS. The WTP operator, Bruce Schlagel, assisted with sample collection at the plant. Mike Dawda of NWRO conducted an operation and maintenance inspection of the WTP.

METHODS

Sampling was conducted September 23 and 24, 1986. On the first day, rain fell lightly and river flows were low. However, rainfall increased overnight and the river rose four feet. Consequently, receiving water sampling was sharply curtailed on day two.

Both composite and grab samples were collected at Arlington WTP. Influent and effluent compositors collected a 220 mL wastewater sample at half-hour intervals over a 24-hour period. The influent compositor sampled the waste stream following comminution, while the effluent compositor sampled from the top of the clarifier. Grab samples were collected periodically from both sites and from the final effluent. A sample for sludge metals was collected as sludge was transferred from the clarifier to a truck for land application.

Instantaneous WTP flows were estimated by head height at the 90-degree V-notch effluent weir. Other parameters measured at the plant were temperature, pH, and specific conductance (Beckman meters), dissolved oxygen (azide-modified Winkler titration), and total residual chlorine (LaMotte-Palin DPD test). Samples for laboratory analysis included alkalinity, oil and grease, turbidity, solids (4), nutrients (4), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and fecal coliforms.

Samples for pH, residual chlorine, and fecal coliforms (grabs), as well as total suspended solids and BOD_5 (composites), were split for separate analysis by the operator and Ecology. The operator composited influent wastewaters by hand, collecting a 450 mL sample hourly from 0700 to 1400 hours on September 24. Effluent samples (450 mL) were automatically composited hourly over a 24-hour period. Sampling locations were as described above. The operator alternates his sole compositor between the influent and effluent on a biweekly basis.

Receiving water sampling on September 23 occurred at four cross-channel transects: river mile (r.m.) 17.71 (just upstream of the outfall), 17.7, 17.6, and 17.5 (Figure 2). Samples were collected by boat at one or two quarter-points and depths along each transect, depending on river width and depth. Samples at depth were collected with a Van Dorn bottle. The outfall was located using Rhodamine WT dye. A buoy was anchored above the outfall to delimit the control station (r.m. 17.71) and the immediate downstream site (r.m. 17.7).

Receiving water sampling on September 24 consisted solely of nearshore grabs from both river forks. Two municipal storm sewer outfalls were also sampled (Figure 2). A third storm sewer ("C") could not be accessed as it was submersed by high river flows.

River discharge was estimated using USGS wire-weight gage heights and provisional USGS stage data (R. Williams, USGS, personal communication). Other field parameters measured during the receiving water work were temperature, pH, specific conductance, and dissolved oxygen. Samples collected for lab analysis included turbidity, nutrients (4), and fecal coliforms.

WTP and receiving water samples for lab analysis were iced and shipped to Ecology's Manchester laboratory for processing as per EPA (1979) and APHA, et al. (1985). Transportation delays resulted in loss of fecal coliform data for the first day. Sample analysis by the operator was completed at the WTP laboratory.

RESULTS AND DISCUSSION

Limited Class II Inspection

Arlington WTP was operating well at the time of the inspection (Table 1). Nitrification reduced ammonia levels considerably, with concomitant reductions in pH and alkalinity. The WTP flow recorder was inoperative, but instantaneous flow measurements at the effluent weir generally agreed with the plant totalizer reading. Flows nearly doubled overnight due to heavy rainfall and consequent infiltration and inflow.

An influent BOD grab was collected on the second day after we noticed a whitening of the incoming wastewater. The operator reported this to be a routine occurrence owing to washdown at the Country Charm dairy. The BOD result was higher than the composite BOD. The operator noted that subsequent 2 mg/L reductions in dissolved oxygen occur in the oxidation ditch, but that final effluent appeared unaffected by the dairy inputs.

Analysis of sludge metals yielded atypical results (Table 2). Four of six concentrations were outside the range found at other municipal WTPs (Heffner, 1985). Cadmium, chromium, and zinc were low relative to other WTPs, while copper was high (no sources were evident). These aberrations were likely a function of laboratory error and thus values reported for all six metals should be regarded as suspect (S. Twiss, Manchester Laboratory, personal communication).

Arlington WTP was in compliance with permit effluent limitations during the inspection (Table 3). Both Ecology and WTP results are shown for comparison. The flow-proportioned addition of chlorine appeared adequate to meet fecal coliform limits.

Split sample analyses indicate the need for a more detailed review of WTP laboratory procedures (Table 4). The operator's TSS results were consistently higher than ours regardless of type or location of sampling. Influent BODs were also higher at the WTP lab. (As expected, influent BODs also showed the manually composited sample to be of greater strength than the automatically composited sample.) Differences in influent pH readings were attributed to lack of two-standard calibration on the WTP's Corning meter. Two initial residual chlorine splits did not match because the operator was unaware of the need to add a

Table 1. Wastewater quality measured during a limited Class II inspection at Arlington WTP on September 23-24, 1986.

			Field							Laboratory												
							Dissolved Oxygen						Solids (mg/L)				Nutrients (mg/L)					
Site	Date	Time	Flow (MGD)	Temperature (°C)	pH (S.U.)	Conductivity (umhos/cm)	(mg/L)	(% Sat.)	Resid. Chl. (mg/L)	Alkalinity (mg/L)	Oil & Grease (mg/L)	Turbidity (NTU)	TS[a]	TNVS[a]	TSS[a]	TNVSS[a]	NO_3-N/ NO_2-N	NH_3-N	Total P.	BOD-5 (mg/L)	COD (mg/L)	Fecal Coli. (#/100 mL)
Influent	9/23	1400	--	18.0	7.5	440	--	--	--	--	33	--	--	--	--	--	--	--	--	--	--	--
	9/24	0920	--	17.0	7.5	360	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	9/24	1145	--	18.3	7.7	440	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	9/24	1425	--	18.1	7.4	470	--	--	--	--	--	--	--	--	--	--	--	--	--	260	--	--
	9/24	Comp.[b]	--	5.4	7.7	400	--	--	--	130	--	34	380	130	110	12	0.41	15	5.9	170	410	--
Oxidation Ditch	9/23	1400	--	--	--	--	--	--	--	--	--	--	5000	1200	4400	880	--	--	--	--	--	--
	9/24	0920	--	--	--	--	--	--	--	--	--	--	4200	980	3800	770	--	--	--	--	--	--
Effluent[c]	9/23	1400	0.46	16.8	6.4	380	1.85	19	--	43	1.0	6	300	160	15	1	22	0.09	6.3	--	44	--
	9/24	0755	0.84	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	9/24	0945	0.50	16.2	6.6	345	2.60	26	0.2	18	--	5	270	130	8	<1	19	0.10	4.9	--	44	100
	9/24	1145	0.35	16.5	6.5	340	2.35	24	0.3	--	--	--	--	--	--	--	--	--	--	--	--	4
	9/24	1425	0.38	16.1	6.4	330	2.35	24	0.5	--	--	--	--	--	--	--	--	--	--	--	--	<4
	9/24	Comp.[b]	0.46[d]	4.4	6.6	360	--	--	--	18	--	6	280	130	13	<1	19	0.08	5.2	12	52	--

[a]TS = total solids; TNVS = total non-volatile solids; TSS = total suspended solids; TNVSS = total non-volatile suspended solids.

[b]24-hour iced composite samples: on at 1330 (9/23), off at 1330 (9/24).

[c]All samples unchlorinated effluent, except fecal coliforms and residual chlorine.

[d]Based in WTP flow totalizer.

Table 2. Results of metals analysis for Arlington WTP sludge and comparison to levels found on previous Ecology surveys at other municipal activated sludge WTPs (Heffner, 1985). All concentrations are in mg/kg dry weight.

Metal	Arlington WTP[a]	Other Municipal WTPs Geometric Mean	Range	Number of Samples
Cadmium	0.099	6.9[b]	<0.1 - 25	28
Chromium	2.8	59.8	15 - 300	28
Copper	4195	366	75 - 1700	28
Lead	240	224	34 - 600	28
Nickel	39.8	22.4[b]	<0.1 - 62	24
Zinc	7.6	1160	165 - 3370	28

[a]Laboratory findings are considered suspect (see text for explanation).

[b]Concentrations below detection limit averaged in at one-half detection limit.

Table 3. Evaluation of NPDES permit compliance during a limited Class II inspection at Arlington WTP on September 23-24, 1986.

Parameter	Units	NPDES Permit Limit Monthly Average	NPDES Permit Limit Weekly Average	Ecology Grab[a,c]	Ecology Composite[a]	WTP[b] Composite
BOD_5	mg/L	30[d]	45	--	12	7
	lbs/day	165	375	--	46[e]	27[e]
	% removal	85	--	--	93	98
Total Suspended Solids	mg/L	30[d]	45	--	13	19
	lbs/day	165	375	--	50[e]	73[e]
	% removal	85	--	--	88	90
Flow	MGD	1.0	--	0.51	--	0.46
Fecal Coliform	#/100 mL	200	400	9	--	--
pH	S.U.	$6 \leq pH \leq 9$		6.5	--	--
Total Residual Chlorine	mg/L	minimum required to meet fecal coliform limit		0.3	--	--

[a]Ecology grab or composite analyzed at Ecology laboratory.

[b]Arlington WTP composite analyzed at WTP laboratory.

[c]Mean values.

[d]Limit is 30 mg/L or 85 percent removal, whichever is more stringent.

[e]Calculated as: 8.34 x 0.46 MGD x concentration in mg/L.

Table 4. Results of sample splits between Ecology and Arlington WTP on September 24, 1986.

				Parameter				
Site	Time	Sampler	Laboratory	pH (S.U.)	Resid. Chl. (mg/L)	TSS (mg/L)	BOD-5 (mg/L)	Fecal Coliform (#/100 mL)
Influent Grab	0945	Ecology	--	7.7	--	--	--	--
		WTP	--	7.2	--	--	--	--
Influent Composite	1330	Ecology	Ecology	--	--	110	170	--
			WTP	--	--	200	214	--
		WTP	Ecology	--	--	130	240	--
			WTP	--	--	200	313	--
Chlorinated Effluent Grab	0945	Ecology	--	6.5	0.2	--	--	100
		WTP	--	6.6	0.1	--	--	0
	1145	Ecology	--	--	0.3	--	--	--
		WTP	--	--	0.15	--	--	--
	1425	Ecology	--	--	0.5	--	--	--
		WTP	--	--	0.5	--	--	--
Unchlorinated Effluent Composite	1330	Ecology	Ecology	--	--	13	12	--
			WTP	--	--	19	7	--
		WTP	Ecology	--	--	11	12	--
			WTP	--	--	19	7	--

second DPD tablet. Results of a third split agreed and the operator has since ordered a supply of DPD #3 tablets.

The office and laboratory facilities at Arlington WTP were neat and the grounds were well-maintained. Loose cinder blocks atop the oxidation ditch appeared unnecessary and should be removed.

Receiving Water Survey

Near-field effects of WTP discharge on the the receiving environment could only be evaluated on September 23 due to rising river flows (Table 5). Discharge was approximately 500 cfs in each fork on the 23rd. The operator measures mainstem gage heights daily and he reported the 1,000 cfs to be fairly typical of summer low flow conditions. Mainstem discharge on September 24 exceeded 6,000 cfs and water quality in both forks clearly declined.

Arlington WTP effluent had minimal impact on riverine water quality. The receiving-water-to-effluent dilution ratio during the survey was 1400:1. Dye studies showed the effluent surfaced within 20 feet of the outfall despite considerable current velocity. Nitrate-nitrite and total phosphorus were the only parameters which changed relative to the upstream control (r.m. 17.71). Effluent nutrient loads were 6 percent and 9 percent of total riverine inorganic nitrogen and phosphorus loads, respectively. Although fecal coliform data were lost, no in-stream bacterial contamination was expected given the high rate of dilution and low fecal coliform densities in WTP effluent.

The new outfall line was originally equipped with a 16- to 12-inch reducer at its terminus, but it broke off during the winter of 1985-86. Dye studies during a reconnaissance survey in October 1985 revealed the same plume characteristics we observed in September 1986. Thus the reducer apparently had little, if any, effect on dilution and dispersion of effluent: location of the outfall alone provided sufficient mixing. However, the outfall line was again washed out by high flows this past winter (1986-87) and effluent is once more being diverted to the side channel (B. Schlagel, WTP operator, personal communication).

Mixing zone dynamics observed during the receiving water survey can best be understood by analysis of nitrate-nitrite data (Table 1; Figure 3). All four samples collected upstream of the outfall had concentrations of 0.18 mg/L. Effluent nitrate-nitrite was initially diluted from 22 mg/L to an average of 0.37 mg/L. Mass balance calculations show the dilution ratio at this point (20 feet below the outfall) to be about 110:1, predicted as follows:

$$(F)(0.18\ \text{mg/L}) + (0.7\ \text{cfs})(22\ \text{mg/L}) = (F + 0.7\ \text{cfs})(0.37\ \text{mg/L})$$

where F = river flow = 80 cfs

and thus dilution = 80/0.7 = 110:1.

Table 5. Water quality in the Stillaguamish River upstream and downstream of the Arlington WTP outfall, September 23-24, 1986.

Sampling Site	River Mile	River Bank[a]	Depth (m)	Date	Time	Flow (cfs)	Temp. (°C)	pH (S.U.)	Cond. (umhos/cm)	D.O. (mg/L)	D.O. (% sat.)	Turb. (NTU)	NO_3-N/ NO_2-N (mg/L)	NH_3-N (mg/L)	Total P. (mg/L)	Fecal Coliform (#/100 mL)
20 feet above WTP outfall	17.71	R	0	9/23	1455	--	12.9	7.6	100	9.95	94	2	0.18	0.01	0.02	--
			2	9/23	1500	--	13.4	7.6	100	--	--	3	0.18	0.01	0.02	--
		L	0	9/23	1505	--	12.9	7.3	109	10.00	94	2	0.18	0.01	0.02	--
			1	9/23	1510	--	13.1	7.3	112	--	--	3	0.18	0.01	0.05	--
		Mean	--	--	--	1,000	13.1	7.4	105	9.98	94	2	0.18	0.01	0.03	--
20 feet below WTP outfall	17.7	C	0	9/23	1510	--	12.9	7.6	100	9.95	94	4	0.31	0.01	0.05	--
			1.5	9/23	1515	--	13.2	7.6	104	--	--	2	0.43	0.01	0.09	--
		Mean	--	--	--	1,000	13.0	7.6	102	9.95	94	3	0.37	0.01	0.07	--
500 feet below WTP outfall	17.6	R	0	9/23	1525	--	13.0	7.3	101	10.00	95	3	0.20	0.01	0.06	--
			2	9/23	1530	--	13.1	7.6	100	--	--	3	0.20	0.01	0.02	--
		Mean	--	--	--	1,000	13.0	7.4	100	10.00	95	3	0.20	0.01	0.04	--
1,000 feet below WTP outfall	17.5	R	0	9/23	1540	--	13.0	7.6	100	9.80	93	3	0.21	<0.01	0.03	--
		L	0	9/23	1535	--	13.0	7.5	100	9.90	94	3	0.20	0.01	0.05	--
		Mean	--	--	--	1,000	13.0	7.6	100	9.85	94	3	0.20	0.01	0.04	--
North Fork	17.8	R	0	9/24	1110	2,400	9.8	7.1	50	10.40	92	63	0.47	0.03	0.12	550
South Fork	18.2	R	0	9/24	1035	4,300	10.4	7.0	40	10.35	92	33	0.34	0.04	0.10	570
Storm Drain A	18.2	--	--	9/24	1020	--	11.8	6.9	50	--	--	3	0.26	0.11	0.14	1,800
Storm Drain B	18.0	--	--	9/24	1050	--	12.8	7.1	55	--	--	4	0.46	0.09	0.04	140

[a]Facing downstream, sampling occurred between right bank and centerline of river (R), left bank and centerline (L), or on the centerline (C).

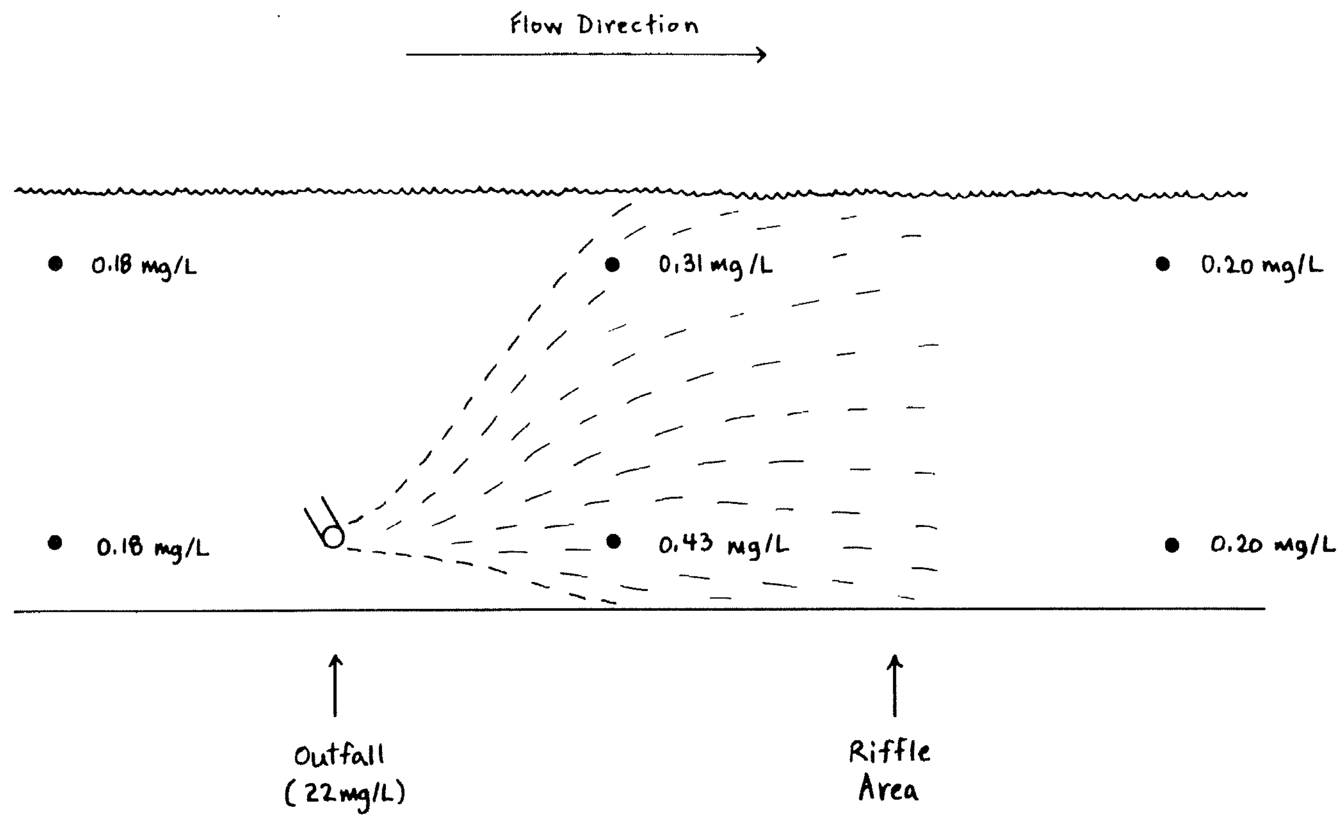

Figure 3. Longitudinal representation of nitrate-nitrite concentrations in the Stillaguamish River upstream and downstream of the Arlington WTP outfall, September 1986.

A riffle area immediately downstream of this point completes the mixing process, as evidenced by the constancy of nitrate-nitrite values at r.m. 17.6 and r.m. 17.5.

Effluent dilution zone guidelines specify that the upper limit of riverine mixing zones shall be one foot below the surface of the water (Ecology, 1985). Technically, therefore, water quality standards should be met where the effluent surfaces. This was the case during the September 1986 survey. To determine if standards would be met in the future under conditions of critical low flow and WTP design capacity, a Total Maximum Daily Load analysis (TMDL) was performed. TMDL analyses model the waste assimilative capacity of receiving environments at "7Q10" flows (i.e., the low mean river discharge expected to occur during seven consecutive days on an average of once in 10 years). Using upstream USGS gage data (Williams et al., 1985), the 7Q10 flow for this reach of the Stillaguamish River is estimated to be 300 cfs. Further, the design flow at Arlington WTP is 1.0 MGD (1.5 cfs).

Unfortunately, one cannot reliably predict the dilution ratio under these conditions at the point in question (surface, 20 feet downstream of the outfall). However, the cross-sectional area occupied by the effluent plume during the survey was very small relative to the total cross-sectional area of the river. In addition, effluent immediately dispersed upon reaching the riffle located directly below the discharge site. Hence it seems more appropriate to perform the TMDL analysis assuming complete mixing of receiving water and WTP effluent.

The river-to-effluent dilution ratio at 7Q10 and WTP design flows would be 200:1. This dilution factor is well above the recommended mix of 100:1 (Ecology, 1985). No violations of state water quality standards are expected to occur given the excellent dilution and dispersion afforded by the Stillaguamish River.

CONCLUSIONS AND RECOMMENDATIONS

- Arlington WTP was operating soundly during a limited Class II inspection in September 1986. The plant was in compliance with NPDES permit limits and the facilities and grounds were well-kept.

- Split sample analyses demonstrated the need for a more detailed review of WTP laboratory procedures in the near future. At that time, Ecology should collect another sample for sludge metals analysis to check the aberrant results obtained in the present study.

- Effluent from Arlington WTP had minimal impact on Stillaguamish River water quality. The receiving-water-to-effluent dilution ratio was 1400:1, well above the recommended mix of 100:1.

- Location of an outfall line installed in September 1985 provided excellent dilution and dispersion of effluent. Unfortunately the line was lost to high flows this past winter and effluent is once again being diverted to a side channel of the river which ponds during low flow periods. Design of a new outfall line should protect against the high flows and unstable sediments characteristic of this portion of the river.

- A TMDL analysis predicted a 200:1 dilution ratio at 7Q10 flows and WTP design capacity. No violations of state water quality standards are expected under these conditions.

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